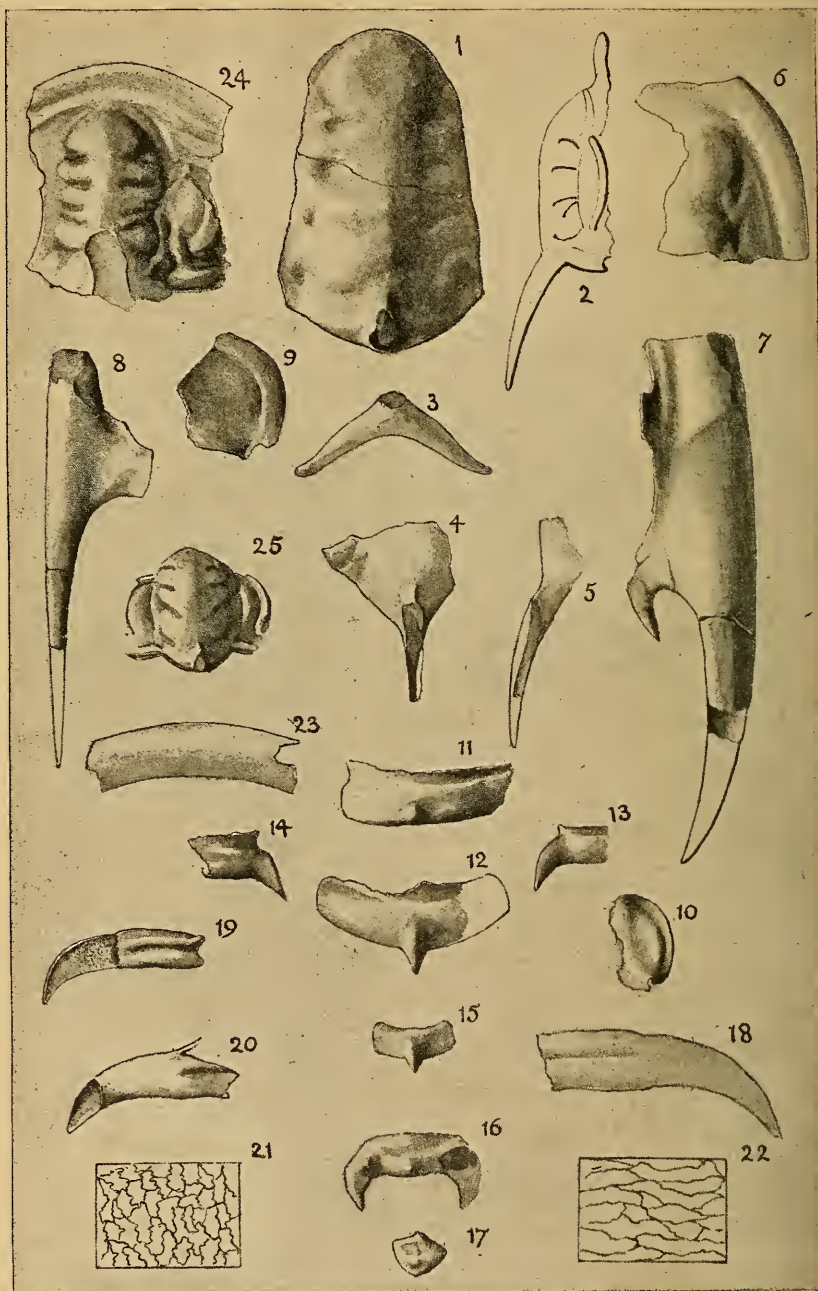
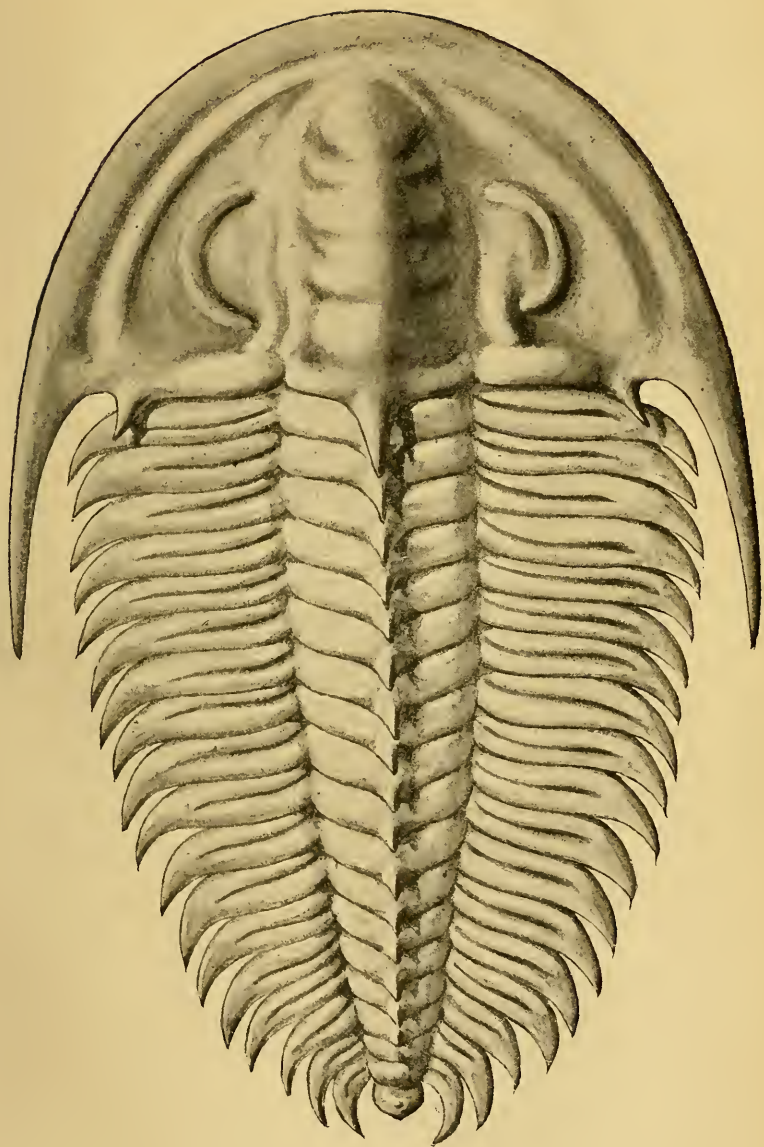




E. C. Woodward, del.

Meisenbach Co. sc.

Olenellus Callavei, Lapworth,
from the Comley, or Hollybush Sandstone, of Shropshire.



Olenellus Callavei, Lapworth,
Comley, or Hollybush Sandstone of Shropshire.

Theoretical restoration, natural size.

THE

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ORIGINAL ARTICLES.

I.—ON *OLENELLUS CALLAVEI* AND ITS GEOLOGICAL RELATIONSHIPS.

By PROF. CHARLES LAPWORTH, F.R.S.

(PLATES XIV. AND XV.)

IN the year 1888 I published a short paper in the pages of the GEOLOGICAL MAGAZINE¹ and in "Nature,"² in which I gave a brief account of the discovery of the fauna of the *Olenellus* (or Lower Cambrian) zone in the Comley or Hollybush Sandstone of Shropshire. Since that date great advances have been made in our knowledge of the *Olenellus* fauna of other areas, and the *Olenellus* zone has now generally attained an established rank and systematic position in the Geological Record as the basal zone of the Cambrian system.

At the time my paper was written sufficient material had been obtained to enable me to recognize the existence of a well-marked species (*Ol. Callavei*) of the genus *Olenellus* in the Comley Sandstone series. But the form appeared to be so closely allied to the *Olenellus Bröggeri*, which had been discovered by Mr. Walcott,—the distinguished palæontologist of the United States Geological Survey—in the basement beds of the Cambrian of Newfoundland, and exhibited and named by him at the meeting of the Geological Congress in London in 1888, that, as I explained in the paper referred to, I felt that it was but just that I should await the appearance of the formal description of his species before publishing my own.

Thanks to the kindness of Mr. Walcott, his brilliant and long-expected Monograph "On the Fauna of the *Olenellus* Zone"³ now lies before me, in which *Olenellus Bröggeri* is admirably figured and described; and although it includes a comparative diagnosis of *Olenellus Callavei*, sufficient for registration and identification, I take this my first possible opportunity of figuring and describing in full our Shropshire form, that the want of acquaintance with its minor specific characters may not delay those who may be desirous of publishing new species from the *Olenellus* zone elsewhere.

¹ Lapworth, "On the Discovery of the *Olenellus* Fauna in the Lower Cambrian Rocks of Britain," GEOLOGICAL MAGAZINE, 1888, Dec. III. Vol. V. p. 485.

² "Nature," vol. xxix. p. 213.

³ See next page.

The fragments figured on Plate XIV. are those which were exhibited by myself at the meeting of the Geological Congress at London in 1888, supplemented by a few others which were at the time in my possession. The majority were collected by Mr. H. Keeping (acting under my instructions with the kindly consent of Prof. T. McKenny Hughes, F.R.S.) during the previous years, and are the property of the Woodwardian Museum, Cambridge.

The restoration attempted on Plate XV. is founded essentially upon these fragments; so that palæontologists will be able to judge for themselves in what respects that restoration is justified or defective.

OLENELLUS (HOLMIA) CALLAVEI, Lapw.

Plate XIV. Figs. 1-25. Plate XV. Fig. 26.

1888. *Olenellus Callavei*, Lapworth, GEOLOGICAL MAGAZINE, Dec. III. Vol. V. p. 485.
 1888. *Ibid.* Lapworth, "Nature," vol. xxix. p. 213.
 1889. *Olenellus Callavei*, Walcott, American Journal of Science, vol. xxxvii. p. 391.
 1891. *Olenellus (Holmia) Callavei* (Lapw.), Walcott, "Fauna of the *Olenellus* Zone," 10th Report Geol. Survey, U.S.A., pp. 640-641, p. 581, etc.

Description.—General form ovate-elliptical, about one and a half times longer than broad. Head broad, semi-circular to semi-elliptical in outline and moderately convex. Margin edged exteriorly by a broad conspicuous rounded rim or flange, and limited interiorly by a faint parallel angular ridge. Posteriorly the margin is broadened and prolonged in a strong rounded spine. The under side of the proximal margin forms a broad rounded doublure. The posterior margin of the head bears two short, stiff, spur-like "interocular" spines, which are directed backward and outward, and are continued interiorly by a faint ridge which appears to be prolonged almost to the crest of the glabella in advance of the occipital furrow.

Glabella broadly convex in elevation, and sub-clavate in outline; attaining its greatest width near the anterior extremity of the eye-lobe, and having a sharply rounded to sub-triangular frontal edge. It is furnished with three pairs of glabellar furrows (with traces of a fourth anterior pair). They occur as shallow and broad double depressions, deepest midway between the axis and the lateral margins, and almost disappearing as they cross the central parts of the glabella. Occipital furrow of the same type as the rest; but broader and deeper, and limited in part anteriorly by a slight but conspicuous ridge (the proximal extension of the "interocular" process?). Occipital ring flat and narrow laterally; rising posteriorly to a strong marginal rim, and rapidly increasing in width and height to its centre, where it insensibly graduates into a stout claw-like spine, which arches backward over the first two (?) segments of the thorax.

Eye-lobes prominent, elongate, narrow, lunate to semi-circular, situated sub-centrally with respect to the height of the glabella; arching outward from the base of the anterior lobe to a distance equal to half the width of the glabella, and backwards almost to a line with the occipital furrow. Visual surface unknown. Area

between glabella and eye-lobe flat, and separated from the glabella by an irregular undulating groove. Frontal limb narrow. Surface of free cheek slightly convex, sloping inwards to the eye-lobe, and outwards to the groove bounding the lateral margin. Thorax with 18 (?) segments. Axial lobe elevated; prominently rounded and narrowing throughout. Each axial segment is well defined. It is thickened posteriorly and laterally grooved; and it bears centrally a short and stout recurved claw-like spine, with a spreading base, and a sharp ridge-like upper surface. The terminal segments bear in addition two lateral rudimentary spurs, while the central spine is much reduced in size. Pleural lobes, flattened for the first half to two-thirds of their length; and then gracefully curving and contracting to the recurved falcate extremity. The proximal surface of each is relieved by an oblique pleural groove.

The associated pygidium is small, simple, almost semi-circular in form; with slightly converging lateral margins, straight and shortened posterior edge, distinct central elevation, and anterior groove.

The test or body-covering of both head and thorax is marked throughout by a raised fretwork of inosculating lines or ridges, the pattern of which varies in different parts.

Dimensions.—The larger fragments collected indicate a length of about six inches and a breadth of about four inches. With the exception of *Olenellus (Holmia) Bröggeri*, Walcott, this form is the largest species of the genus yet discovered.

Comparisons.—*Olenellus Callavei*, as I have already more than once pointed out,¹ is most intimately allied to *Olenellus Kjerulfi*, Linnarsson, from the Lower Cambrian of Norway, and *Olenellus Bröggeri*, Walcott, from the basal beds of the Cambrian of Newfoundland. These three species appear to me to constitute a special sub-generic (?) group, intermediate between *Olenellus*, Hall (including *Mesonacis*, Walcott, and *Olenoides*, Meek). They all possess the remarkable "interocular" processes and conspicuous dorsal spines of the latter, but differ in the absence of the facial suture. They agree with *Olenellus* (including *Mesonacis*) in the general form of the head and of the glabella, and in the peculiar ornamentation of the test; but differ in the absence of the great median or terminal spine. From both groups they are strikingly distinguished by the great development of the occipital process. In allusion to this common characteristic feature, I suggested for the group the title of *Cephalacanthus*; ² but, as Mr. Walcott has pointed out, this term must give way to *Holmia*, the subgeneric title published by Mr. Matthew³ in June, 1890, for *Olenellus (Holmia) Kjerulfi*, Linnrs., the first discovered species of the group.

Olenellus Callavei not only agrees with *Ol. Kjerulfi* in its general characters, but in the conspicuous development of the interocular spines, in the existence of a faint ridge sweeping back from the

¹ GEOL. MAG. etc., *loc. cit. supra*. Fauna *Olenellus* Zone, pp. 640–641.

² GEOL. MAG. 1888, p. 641.

³ Matthew, Trans. Roy. Soc. Canada, 1890, p. 160.

spine almost to the axis of the glabella just in advance of the neck furrow; in the double character of the lobes and furrows of the glabella itself, and in the form and position of the eyes. It differs from *O. Kjerulfi* in its larger size, and more compact habit; in the rapid contraction of the glabella towards the front, in the much greater development of the occipital spine, and in the falcate character of the terminal parts of the pleuræ.

O. Callavei agrees, on the other hand, with *Ol. Bröggeri* in all those features which distinguish the former from *O. Kjerulfi*; and differs from it in all those characters which are common to the English and Norwegian forms. In addition, a minor distinction is constituted by the much greater extension of the genal and interocular processes in *O. Callavei* than in *O. Bröggeri*, and a much lesser extension of the great occipital spine.

The form is dedicated to my friend Mr. Charles Callaway, D.Sc., F.G.S., who was the first to detect organic remains in the Comley Sandstone, and the first to demonstrate the presence of true Cambrian fossils in Shropshire generally; and whose original and sagacious inference as to the probable pre-Cambrian age of the unconformably underlying rocks the discovery of *Olenellus* places beyond much dispute.

In addition to the fragments upon which the foregoing description has been mainly drawn up, a few figures (Figs. 24 and 25) are given on Plate XIV. of younger examples of the species, in which the same characteristic features will be recognized.

Olenellus Callavei occurs in a highly calcareous bed of bright purplish-red calcareous sandstone, or sandy limestone, near the base of the Comley Sandstone (Hollybush) series of Central Shropshire. The figured specimens were all procured from a single locality—the Comley Quarry—at the foot of the hill of Little Caradoc, near Church Stretton. In this district the *Olenellus*-bearing sandstone passes down into olive-green feldspathic flags, grits, and concretionary shales, and the base of the entire Comley Sandstone series is formed of the well-known Caradoc or Wrekin Quartzite, which reposes unconformably upon the Volcanic Uriconian Group of Callaway. The *Olenellus*-bearing beds are overlain at once by conglomerates, and gritty and quartzose strata, containing abundant fragments of igneous rocks, concretions of carbonate of copper, calcareous bands, and limy nodules; and these in turn pass up into flaggy shales and quartzose grits, forming the highest visible parts of the Comley series.

Olenellus Callavei appears to be strictly confined to that part of the Comley series which lies below the conglomerate bands mentioned above; and its associates include *Kutorgina cingulata*, *Linnarssonia sagittalis*, *Hyolithellus* (compare *H. micans*, Walcott) and *Elliptocephalus*, sp.

The overlying conglomerates and limestones are distinguished by the presence of a large species of *Paradoxides* (*P. Groomii*¹ sp. nov.), together with forms of *Ptychoparia*, *Obolella*, *Protospongia*, etc.

¹ *Paradoxides Groomii*, sp. nov. In general form and size intermediate between

The generic position of the two characteristic forms of the Lower and Upper Divisions of the Comley Series being thus settled, the descriptions of the less important associated forms may conveniently be deferred to a more favourable occasion.

We possess in the foregoing facts sufficient palæontological evidence to establish the Lower Cambrian age of that part of the Comley series which contains the genus *Olenellus*; and we have now obtained stratigraphical and palæontological proof that it is succeeded at once by the so-called Middle Cambrian or *Paradoxidian*. Further, as Dr. Callaway¹ originally pointed out some years ago, the Hollybush (or Comley Sandstone) series is followed in turn by the Shineton Shales, which contain locally a fauna of highest Cambrian age. In these Central Shropshire rocks, therefore, the Comley and Shineton Groups, which constitute an integral part in this district of Murchison's original *Lower Silurian*, and have a collective thickness of perhaps less than 3000 feet, we have apparently a condensed epitome of the entire Cambrian system as at present generally defined.

Here, as elsewhere, we find the Cambrian divisible into three sections—an Upper Cambrian above, marked by the presence of the genus *Olenus* (Olenidian); a Middle Cambrian group with *Paradoxides* (Menevian or Paradoxidian); and finally a Lower Cambrian (*Olenellus* zone) or basal group (possibly of somewhat different systematic importance), distinguished by the presence of *Olenellus*. No one has yet, so far as I know, suggested any general title for the basal division of the Cambrian. Recollecting, however, that the very first discovered species of the genus *Olenellus* was named and figured² by the American geologist, Dr. Emmons, as early as 1846 from the rocks of his Taconic or Taconian system; and was claimed by him as early as 1853³ as coming from strata older than any of the fossil-bearing Silurian (including the Primordial zone) then discovered; while even at the present day the genus holds its own as marking a distinct and identifiable life-zone in the strata of Emmons' typical Taconic area; it would be very convenient if geologists and palæontologists generally would agree in calling it the Taconian.

In my short paper already referred to, "On the Discovery of the *Olenellus* Zone in Britain," I drew a few provisional inferences, novel at that time, but thrown out then as "constituting a provisional working hypothesis, of service mainly as a guide and *Par. Harlani* (Green) and *Par. Davidis* (Salter). Length 8 to 9 inches, breadth $5\frac{1}{2}$. Head semi-circular, with pointed genal spines from two to three inches in length. *Glabella* prominent, clavate, more than half its length being occupied by the broadly rounded and smooth frontal lobe. *Hypostoma* of the type of that of *Par. Bohemicus* (Boeck). *Pleurae* (no ?) falcate, and sharply pointed. Pygidium a raised disc with central tubercle; embraced laterally by long, sabre-like, distally-diverging spines. *Localities*. Neves Castle (Lapw., 1889) and Comley (Groom, 1890). Named after T. Theo. Groom, Esq., B.Sc., who first collected fragments sufficient for description.

¹ C. Callaway, "Upper Cambrian Rocks in South Shropshire," Q.J.G.S. 1877, p. 652, etc.

² As *Elliptocephala asaphoides*, Emmons, Taconic System, 1846, p. 213, figs. 1, 2, 3.

³ Emmons' American Geology, 1855, pt. ii. pp. 6 and 7, etc.

stimulus to future discussion, investigation, discovery and correction." It is somewhat instructive to note how—taking the publication of these provisional inferences as our starting point—geological knowledge and opinion in this department has advanced in the interval. These theoretical conclusions were three in number, and for the sake of comparison—the contrasts between them (as paraphrased from their original crude form), and their present aspect (in so far as can be deduced from the actual state of geological opinion),—may very briefly be summarized as follows:—

(a) The presence of *Olenellus* in these Shropshire strata appears to fix the pre-Cambrian age of the Uriconian Series of Dr. Callaway, and to render the pre-Cambrian age of his Longmyndian a matter of fair probability.

Since 1888, Professor Blake, who has of late years added very much of great value to our knowledge of the Cambrian and pre-Cambrian rocks, unhesitatingly assigns the lower zones of the Longmynd Series of Callaway to his own Monian, or pre-Cambrian.¹ Sir A. Geikie, after studying the *Olenellus*-zone and the overlying and underlying rocks in the field, has frankly expressed his view that the Uriconian may be of pre-Cambrian age.² Finally, the fact brought forward in the present paper—namely that representatives of all three divisions of the true Cambrian, as at present acknowledged, are actually known to occur in Central Shropshire, being mapped as constituting an integral part of Murchison's original Lower Silurian,—renders it very unlikely that the Longmyndian (the original pre-Silurian or Cambrian of Murchison and the other great stratigraphists who immediately followed him) can be anything else than pre-Cambrian.

(b) The so-called Upper Cambrian of the Malverns, Central England and N.W. Scotland may be in reality a greatly attenuated representative of the entire Cambrian system; part of an originally fairly continuous Cambrian once extending from Lapland through Britain and Europe to Sardinia—and the Sardinian and Durness formations may both range down to the base of the Cambrian.

The recent brilliant discovery of *Olenellus* by the officers of the Geological Survey of Scotland,³ in the Fucoid and Salterella zone, in the lower parts of the Durness-Eriboll Series, establishes the correctness of this suggestion for the N.W. Highlands. The detection of *Paradoxides Groomii* in the supra *Olenellus*—infra *Olenidian*—zones of Central Shropshire, as described in the preceding pages of the present paper,⁴ appears to settle the matter equally satisfactorily as regards Southern Britain:—

(c) If so the Torridon Sandstone of North West Scotland would possibly go with the Longmyndian into the pre-Cambrian, the Schists of St. Lo in France, and the rocks of corresponding antiquity elsewhere.

Here, again, this provisional conclusion has been extended and left far behind by later research and opinion. As already pointed out by Sir A. Geikie,⁵ the discovery of *Olenellus* in the Durness-Eriboll

¹ J. F. Blake, On the Monian and Basal-Cambrian Rocks of Shropshire, Q.J.G.S. 1890, p. 386, *et. seq.*

² Sir A. Geikie, Anniversary Address, Q.J.G.S. 1891, pp. 86–90.

³ Sir A. Geikie, GEOL. MAG. 1891, p. 449.

⁴ See *ante* p. 532.

⁵ *Ibid.* p. 449.

Series fixes the pre-Cambrian age of the Torridon Sandstone. Again, Dr. Katzer¹ has shown that the strata of the Bohemian Urgeberge (the Cambrian² of Barrande and Murchison—Etages A. and B.) lie (at least locally), unconformably below the rocks of the true Cambrian or Primordial zone (a conclusion recently confirmed by Dr. Wentzel³) and must, therefore, be now classed as pre-Cambrian or Archæan. In precisely the same way in two recent and most valuable memoirs by M. Bergeron and M. Bigot we are presented in one area (N.W. France) with clear physical proofs,⁴ and in another (Languedoc) with actual palæontological evidence,⁵ that the condensed Cambrian of Central Britain is apparently prolonged through France from the Channel Isles to the Montagne Noire; and as a consequence the underlying (often unconformable) schists of St. Lo, etc.—i.e. the Cambrian of Dalimier, Dufrenoy and Murchison—may now be regarded as of Archæan or pre-Cambrian age.

Thus while we have still very much to learn respecting the fossils, the component members, and the local development of the ancient Palæozoic strata, and while we must admit that many of our present inferences and conclusions lie open to improvement and correction by future investigation and discovery—the students of these old rocks (however much they may conscientiously differ in the provisional nomenclature in which they clothe their facts) have now all more or less attained to the conviction that we are at last reaching a satisfactory homotaxial base to the Palæozoic rock-series. We now see that the Lower Palæozoic cycle of formations (the Protozoic or Protogean) or the Silurian of Murchison's '*Siluria*' and Barrande's '*Système*' has proved itself to be a geological cycle of the first order. We agree, in principle, that it is made up (like each of the succeeding great cycles), of three sub-equal groups⁶ or systems—an Upper system (the *Silurian* proper, or *Salopian*) a Middle system (the *Ordovician*) and a Lower system (the *Cambrian*). This lower system, like each of the two systems above it, has now shown itself divisible in its turn into three sections—an Upper Cambrian (*Olenidian*), a Middle Cambrian (*Paradoxidian*) and a Lower Cambrian (*Taconian*).

Underneath this Cambrian lie sometimes conformably, sometimes unconformably, the strata of the mysterious cycles of the Pre-Cambrian (or Archæan). Of these, certainly the rocks of the unaltered divisions (the Eozoic or Eogean cycle) are now so well circumscribed geographically that there appears little to hinder their detailed study and investigation by an extension and development

¹ Dr. Fr. Katzer, Das ältere Palæozoicum in Mittel Böhmen, Prague, 1888, pp. 5, 7.

² *Siluria*, 4th edition, p. 273.

³ Dr. Josef Wentzel, Die Beziehungen der Barrandischen Etagen C, D, E zum Britischen Silur., Jahrbuch d. k. k. Reichsanstalt, Wien, 1891, p. 119.

⁴ A. Bigot, L'Archéen et le Cambrien du Massif Breton, Cherbourg, 1890, pp. 25, 73, etc.

⁵ J. Bergeron, Etude géologique du Massif ancien du Plateau Central, Paris, 1889, p. 78, pl. ii.

⁶ The *Silurien supérieur*, *Silurien moyen*, and *Silurien inférieur* respectively, of the younger French geologists.

of the same rules which have been employed in satisfactorily determining the order and the characteristic organic remains of the more recent systems. Surely it is not too much to hope that the day is fast approaching when these Eozoic formations will be reduced to their natural order as fossil-bearing systems, comparable in all respects (except in the greater paucity of their organic remains) with the Post-Archæan systems which at present form the accepted members of our great geological scale.

EXPLANATION OF PLATE XIV.

- FIG. 1. *Olenellus Callavei*. Glabella in relief, showing the characteristic shape, the lobes and furrows, and the broken base of the occipital spine.
- FIG. 2. ———— Do. Side elevations.
- FIG. 3. ———— Occipital lobe with base of central process. Posterior aspect.
- FIG. 4. ———— Fragment of hinder part of glabella, etc., from above, showing size and length of a broken occipital spine.
- FIG. 5. ———— Do. Side elevation.
- FIG. 6. ———— Fragment of part of head, showing marginal and interior ridges.
- FIG. 7. ———— Terminal part of free cheek with marginal ridge, and genal and "interocular" spines.
- FIG. 8. ———— Do. Another and smaller example.
- FIG. 9. ———— Eye lobe.
- FIG. 10. ———— Do. Smaller example.
- FIG. 11. ———— One of the anterior segments of the axis, showing the form and position of the median spine.
- FIG. 12. ———— Do. From central parts of axis.
- FIG. 13, 14. ———— Do. Profile views.
- FIG. 15. ———— Segment of axis near posterior end.
- FIG. 16. ———— Sub-terminal (?) segment of axis, showing central and lateral tubercles.
- FIG. 17. ———— Pygidium.
- FIG. 18. ———— One of the proximal pleuræ, showing general form, pleural groove, and falcate extremity.
- FIG. 19, 20. ———— Pleuræ from near posterior end of thorax.
- FIG. 21. ———— Superficial ornamentation of test. (Magnified.)
- FIG. 22. ———— Ditto. (Magnified.)
- FIG. 23. ———— Doublure for attachment of hypostoma.
- FIG. 24. Young form of *O. Callavei*, showing general form and characters of the glabella, eyes, frontal margin, etc.
- FIG. 25. Do. Another example.

(All the fragments figured, except Figs. 21 and 22, are of the natural size.)

Figs. 18, 19, 20, 24, are from my own Collection, the remainder are in the Collection of the Woodwardian Museum, Cambridge.

PLATE XV.

- FIG. 26. *Olenellus Callavei*, Lapw. Theoretical restoration, natural size.

II.—PETROLOGICAL NOTES ON SOME LAKE DISTRICT ROCKS.

By W. MAYNARD HUTCHINGS, Esq.

DURING the last three years I have at various times collected and studied rocks from the Lake District. Some of them are, I think, of sufficient interest to render them worth describing. It is my opinion that a great deal of very interesting petrological work still remains to be done among these rocks, and that when they are